# Oxygen-14 Beam Development for BEARS

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Oxygen-14 is the second beam being developed for BEARS after it's successful commissioning with Carbon-11 [1,2]. The project couples nuclide production at the Life Sciences Division's Biomedical Isotope Facility (BIF), with acceleration and experimentation at the 88-Inch Cyclotron.

Oxygen-14 is produced by a 10 MeV proton beam on a nitrogen gas target, via $^{14}N(p,n)^{14}O$. This is the same target that produces the $^{11}C$ nuclide currently used in BEARS, and early tests suggested that an $^{14}O$ beam could be produced with only minor additional development. However, when full production tests were conducted at BIF, it was found that very little $^{14}O$ was extracted from the target in a chemical form suitable for use in the transport and cryogenic separation systems of BEARS.

Extensive literature exists on the production, for PET studies, of Oxygen-15 via the reaction of deuterium beams on nitrogen gas targets [3,4]. The techniques developed for PET research generally involve the addition of an oxygen-containing "carrier" to the target gas. For example, the addition of carbon dioxide causes most $^{15}O$ to be produced in the form of $[^{15}O]CO_2$, the ideal form for use in BEARS. However, these techniques generally only work with a fraction of carrier greater than 0.5% of the total target gas. While sufficient for PET studies, this amount is at least two orders of magnitude greater than can be tolerated by the ion source of the 88-Inch Cyclotron (the isotope of interest cannot be separated from the chemically indistinguishable carrier).

Several attempts were made to control target chemistry. These efforts failed, primarily due to the intensely ionizing radiation fields present inside the 13ml target during bombardment with 30 μA of protons. The fields break up the original molecules into atoms and radicals [5]. Oxygen radicals and ions react only very weakly with nitrogen and are lost when they come in contact with the walls of the target. Any oxygen-containing carrier ($CO_2$, CO, $O_2$), added to react with the $^{14}O$ atoms before they are lost (or to combine with the atoms on the target wall and return them to a gaseous form), will also be radiolytically processed, irreversibly diluting the $^{14}O$. The only method identified to extract the isotope from the high-radiation environment, without adding an oxygen-containing carrier, has been the use of hydrogen.

Hydrogen (5%) added to the nitrogen target gas effectively forces the $^{14}O$ into the form of $H_2{}^{14}O$, without dilution by regular water [4]. However, water vapor cannot be effectively utilized by the BEARS transport system, due to sticking in the long transport line.

To overcome this problem, we have been developing a system for rapid chemical conversion of water vapor to carbon dioxide. In the initial step, the water vapor is passed over high temperature carbon, converting it to carbon monoxide ($H_2{}^{14}O$ + carbon(950°C)   $C^{14}O + H_2$). The $C^{14}O$ can then be oxidized to carbon dioxide in a number of ways, such as reaction with added oxygen over a platinum catalyst. The system is currently being tested. Difficulties being worked out include some isotopic-exchange effects, as well as general problems associated with handling extremely small quantities of the molecules of interest.

*Footnotes and References*

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1. see past annual report submissions on BEARS.
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3. D. B. Mackay et al., Appl. Radiat. Isot. 51 (1999) 403.
4. R. A. Ferrieri and A. P. Wolf, Radiochim. Acta 34 (1983) 69.
5. P. Ausloos (Ed.): *Fundamental Processes in Radiation Chemistry*, New York, Wiley (1968).